PROC. ENTOMOL. SOC. WASH.
103(2), 2001, pp. 274–281

# NOTES ON TRAP-NESTING SRI LANKAN WASPS AND BEES (HYMENOPTERA: VESPIDAE, POMPILIDAE, SPHECIDAE, COLLETIDAE, MEGACHILIDAE)

KARL V. KROMBEIN AND BETH B. NORDEN

Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0188, U.S.A.

*Abstract.*—A trap-nesting study was conducted in Kandy, Sri Lanka, during February to June 1997. Wooden pieces ca. 17 cm long with central grooves of either 3 or 5 mm in diameter were placed outside our residence, providing nesting sites for stem-nesting Hymenoptera. A diversity of solitary wasps and bees, including two new species of *Anthidiellum,* were found nesting in these "artificial stems." Evidence of supersedure was noted, and we give the first report of a probable new subgenus of *Hylaeus* that uses a mixture of resin and sand for cell construction. Notes on nest architecture are provided for the observed trap-nesters belonging to the families Vespidae, Pompilidae, Sphecidae, Colletidae, and Megachilidae.

*Key Words:* Sri Lanka, trap-nest, stem-nesting, Hymenoptera, Vespidae, Pompilidae, Sphecidae, Colletidae, Megachilidae

We spent about four months in Sri Lanka, February to June 1997, and were based in the city of Kandy. During the period 9 February through 8 April we rented a large home of relatively recent construction in the Anniewatte suburb near the Botanical Garden at Peradeniya. The house was on a single level, and as is customary in tropical housing, there were louvers above the exterior doors and windows to promote air circulation and to exclude vertebrates. A diverse population of solitary wasps and bees nested in borings in the wooden framing of louvers and the wooden pieces that formed the vanes of the louvers.

Cooper (1953) and Krombein (1967) demonstrated the effectiveness of wooden trap-nests in attracting twig-nesting solitary wasps and bees. These traps were made in blocks of straight grained wood of variable sizes, being 75–152 mm long and 20–25 mm wide. A hole 64–152 mm long was drilled in the center of each block to a distance 13 mm from the end of the block. When nests were completed, they were split longitudinally along the midline so that the nest architecture, prey and development of brood could be noted. Medler and Fye (1956) successfully used as traps, holes drilled in sumac (*Rhus*) stems.

We had some wooden traps of different construction that had been made by the late Paul D. Hurd, Jr. His traps were made from wooden pieces glued together (Figs. 1, 2). We set out a total of 25 traps between a pair of vanes in the louvers, and in a dozen bundles of four, two of each diameter routing, in the crotches of tree branches on the property. The routings in the traps were 3 to 5 mm wide and about as deep. The routings were made in pieces of wood 15.2 cm long, 12.7 mm deep and 19 mm wide; the

routing was made down the middle of the 19 mm side. A strip of wood 16.5 cm long, 19 mm wide and 6.4 mm thick was glued above the routing so that it protruded 12.7 mm beyond the end of the piece containing the routing; a square of wood 19.1 × 19.1 mm and 6.4 mm thick was glued to the other end to seal the basal end of the trap. This kind of trap had not previously been tested in the field.

We examined the traps daily when we were in Kandy. Five traps were sealed at the entrance between 16 March and 1 April. We sealed each trap in a plastic Whirl-pak® in which we made pin pricks for ventilation.

In preparation for our move to new housing in Kandy we gathered all the traps on 4–5 April. We probed each with a grass stem to determine occupancy, and sealed in individual Whirl-paks eight traps that were partially filled. Nests were completed in most of the eight traps but dates of nest completion are unknown. Findings from this study are detailed below.

## Family Vespidae

### *Subancistrocerus sichelii* (Saussure)

Nest #15 was only partially filled on 5 April when we removed it from one of the louvers. We kept it in a sealed Whirl-pak until we opened the trap on 5 May. The routing was 3 mm wide and 2.5 mm deep. The basal 10.2 cm of the routing was empty and capped by a mud partition 2 mm thick. The single cell was 17 mm long including a mud cap 1 mm thick. It contained a silken cocoon spun against the cell walls and a newly enclosed, fully colored, 9.4 mm long male of *S. sichelii.*

Apparently the vespid foundress had been superseded by an anthidiine bee, because there was a pollen mass 3 mm long and traces of resin between the capped cell of *S. sichelii* and the nest entrance.

### *Hylodynerus wickwari* (Meade-Waldo)

We found a female of *H. wickwari,* 7.5 mm long, in the apical part of a routing in nest #13 that also contained a single cell of *Hylaeus sedens* Snelling (see below). There was no evidence of nest construction by the vespid, but she had spent the previous night in the trap.

### *Rhynchium brunneum* (Fabricius)

D. K. Wijayasinghe placed some of our traps on trees at her family home in Ellepola, Palapathwela. She reared a large female of *Rhynchium brunneum* from a trap placed horizontally on a cashew tree 1.3 m above the ground. It had an enlarged routing 13 mm wide and deep with a rounded bottom.

## Family Pompilidae

### *Auplopus mutabilis* (Smith)

We noted that nest #1 had been capped at the entrance by 16 March. We placed the nest in a sealed Whirl-pak. Two pairs of *A. mutabilis* were crawling rapidly around within the Whirl-pak on 1 April. We noted one male trying to mate with a female.

Upon opening the trap we found the routing to be 3 mm wide and deep. The basal end was empty, and the foundress had placed a mud plug 6 mm thick 7.2 cm from the basal end. There was then a series of four cells, each containing silken cocoon remnants; the cells from the innermost were 10, 7, 12, and 9 mm long including the mud seals capping the cells which were 2 mm thick in cell 1, and 1 mm thick in the others. Beyond the provisioned cells was a vestibular cell of 24 mm including a mud plug 2 mm thick, and finally a terminal cell of 6 mm including the 0.5 mm thick plug at the routing entrance. Considering the smaller size of males, it seems probable that females developed in cells 1 and 3, males in 2 and 4. We picked up nests #8 and #23 on 5 April; neither was capped at the entrance but both had been plugged some distance from the basal end of the routing. The nests were placed unopened in individual sealed Whirl-paks.

Three males of *A. mutabilis* emerged

from nest #23 into the Whirl-pak on 16 April. The routing was 3 mm wide and deep, and there was a mud plug 2 mm thick at the base. There followed a series of three cells containing cocoon fragments. Each cell was 10 mm long, including closing mud plugs 2 mm thick. A fourth cell contiguous to cell 3 was 18 mm long with a mud plug 8 mm thick; it contained a cocoon that held a shriveled, post-defecated larva. Contiguous to cell 4 were two empty cells, the innermost was 11 mm long including a mud plug 3 mm thick, the outermost was 10 mm long of which 2 mm was the final mud plug. The apical 9 cm of the routing was empty. The largely undamaged silken cocoon in cell 1 was 6 mm long, closely woven, creamy, ovoid anteriorly and tapering to the narrow posterior 0.5 mm apex containing the meconium.

A female of *A. mutabilis* emerged 26 April from the third nest, #8. The routing was 4 mm wide by 3 mm deep, the basal end was empty and there was a plug of mud 2 mm thick 10 cm from the base. Beyond this plug was the only provisioned cell, 9 mm long, of which 1.5 mm was the mud partition that sealed the cell. Next was a vestibular cell 9 mm long including the 1.5 mm thick mud plug. The rest of the routing was empty. The foundress had done one thing omitted by the makers of nests #1 and #23–she had put a thin layer of mud on the ceiling just above the routing. She was possibly reacting to some glue used to seal the trap.

## Family Sphecidae

### *Pison punctifrons* Shuckard

Four nests were occupied by this species. The foundress sealed the entrance to nest #2 with mud on 27 March, and we placed it in a plastic Whirl-pak on that date. A pair of *P. punctifrons* emerged 27–28 April while we were in the field. We opened the nest on 30 April. The routing was 3 mm wide and deep; the basal 5 mm of the routing was empty and capped by a mud partition 0.5 mm thick. The first cell was 13 mm long, including a thin mud cap 0.5 mm long; it contained an ovoid, delicate, light brown, silken cocoon 9 mm long, apparently that of a species of *Trypoxylon,* and some dry spider fragments beyond the apex of the cocoon. There followed an empty intercalary cell 7 mm long, capped by a thin mud partition 0.5 mm thick; we do not know whether this cell was capped by the foundress *Trypoxylon,* or by a female of *P. punctifrons* to mark its supersedure of the nest. Cell 3 was 12 mm long including the 0.5 mm mud cap, and contained brittle *Pison* cocoon fragments. Cell 4 was an empty intercalary cell 6 mm long with the usual thin mud plug. Cell 5 was 13 mm long with a mud cap 0.5 mm thick; it contained brittle fragments of a *Pison* cocoon. Cell 6 was an empty intercalary cell 20 mm long with a thin mud plug. Cell 7 was an empty vestibular cell 11.3 cm long with 1.0 mm mud plug at the nest entrance.

We picked up nest #9 on 4 April, probed it with a grass stem and found it blocked below the entrance. We placed it in a Whirl-pak® and split it open on 5 May. The routing was 4 mm wide and 5 mm deep and contained a mud plug 1.5 mm thick at the basal end. Cell 1 was 11 mm long including the 0.5 mm thick mud plug; it contained only dead spiders. Cells 2 and 3 were 7 mm long including a 0.5 mm closing plug; each contained a brittle *Pison* cocoon. Cell 4 was partially stored with dead spiders; some spiders dropped out of the open end of the nest and were lost. A female and male *P. punctifrons* emerged from the cocoons on 8 May.

Nest #14 was blocked 7.2 cm inside the trap entrance when we picked it up on 4–5 April. Four *P. punctifrons,* three females and one male, emerged from the nest the morning of 3 May. There was a mud plug 1 mm thick at the basal end of the routing. The positions of the cell partitions had been obliterated by movements of the occupants before their emergence.

Nest #19 was only partially filled when

we picked it up and placed it in a Whirl-pak on 5 April. We opened the nest 5 May and found a mud plug 1 mm thick 5.5 cm from the basal end. There were two completed cells, each with a *Pison* cocoon, and a third incomplete cell with a few dead spiders. Cell 1 was 15 mm long including the 1 mm plug, and the cocoon was 9 mm long. Cell 2 was 8 mm long with a 1 mm cap, and the cocoon was 6 mm long. A female wasp emerged 10 May, and a second wasp escaped from the Whirl-pak.

The dead, sometimes damaged spiders from cells 1 and 4 of nest #9 were identified by W. P. Wijesinghe as follows:

Theridiidae ?—1 juvenile, gen. & sp. indet.

Araneidae—1 juvenile of a species of *Cyrtophora* Simon ?
1 juvenile of a species of *Neoscona* Simon
2 adult and 1 subadult males, gen. & sp. indet.
7 juveniles and juvenile females, possibly conspecific with species above
1 fragmented juvenile, gen. & sp. indet.
2 juveniles, gen. & sp. indet.

Oxyopidae—1 juvenile, gen. & sp. indet.

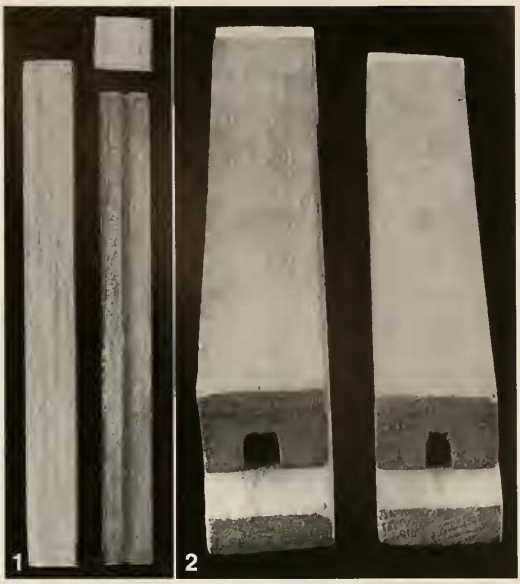
Salticidae—1 juvenile of a species of *Brettus* Thorell
2 juveniles of species 1 of *Rhene* Thorell
2 juveniles of species 2 of *Rhene* Thorell
2 juveniles, possibly different taxa

Family indet.—1 juvenile, gen. & sp. indet.

Wijesinghe commented (in litt.) that the families represented suggest that the nest foundress ". . . had hunted for prey among vegetation."

### *Trypoxylon buddha* Cameron

This slender wasp, 8–10 mm long, was reared from two nests. Nest #3 was completed on 27 March and placed in a sealed Whirl-pak. We opened the trap on 5 May to ascertain nest structure and development.




Figs. 1–2. Hurd trap nest. 1, Component parts: end piece 19 mm square and 6 mm thick to seal inner end of trap; routing 3 mm wide in bottom piece 15.2 cm long; top piece 16.5 cm long to seal top of routing. 2, Two assembled traps oblique from beneath with routings 5 mm wide (left) and 3 mm wide (right).

The routing was 4 mm wide and 3 mm deep. The basal end was empty for 5.5 cm and sealed by a mud partition 0.5 mm thick. Cell 1 was 15 mm long including the 0.5 mm thick cap; it contained a light brown, silken, ovoid cocoon 9 mm long attached to the base of the cell. Next was an empty intercalary cell 15 mm long including a mud cap 1 mm thick. The second brood cell was 20 mm long including the 1 mm thick closing cap; it contained a cocoon of similar size, shape and color as that in cell 1. The remainder of the routing contained a vestibular cell 4.8 cm long including the closing mud cap 0.5 mm thick at the routing entrance.

Nest #4, in a routing 3 mm wide, was completely sealed on 30 March and opened on 5 May. The basal end was empty for 15.5 cm with a 0.5 mm thick seal capping it. Two partial mud seals were 18 and 22 mm beyond this inner mud seal, then a complete 1 mm seal and an empty cell 6

mm long with a 1 mm thick seal. The next cell was 12 mm long including the 1 mm cap; it contained a light brown, ovoid silken cocoon 9 mm long. Beyond that cell was a vestibular cell 3.4 cm long including the 1 mm thick mud cap at the routing entrance.

Another *Trypoxylon* nest, nest #2, has already been discussed under *Pison punctifrons*. The nest had been founded by a species of *Trypoxylon* which had capped the first cell and the nest was then superseded by *P. punctifrons*. The first cell contained a light brown, silken *Trypoxylon* cocoon, 9 mm long.

It is probable that this nest was made by *T. buddha*. The cocoon is the same size and color. Furthermore, *T. buddha* was the more common species that we collected around our home; our total catch of *Trypoxylon* by net around the house was nine females of the slender, elongate *T. buddha* and one female of the somewhat stockier, shorter *T. errans* Saussure.

Colletidae
*Hylaeus sedens* Snelling
(Figs. 3, 5)

This nest, #13 was placed in the louver above one of the doors. We shone a flashlight into the trap on 4 April and saw the head of a wasp near the entrance. We gathered the trap on 5 April; probing with a grass stem indicated that the bore hole was occupied to within 2 cm of the entrance. We placed the nest in a Whirl-pak, and later that day a brightly marked female vespid wasp, 7.5 mm long, *Hylodynerus wickwari* (Meade-Waldo), emerged into the Whirl-pak. The nest was kept in the Whirl-pak and a female *Hylaeus sedens,* 6.5 mm long, emerged on 4 May.

The unicellular nest was in a 5 mm routing. There was a 2 mm thick plug of resin and sand grains 7 cm from the basal end. The cell was 15 mm long including a 1.5 mm thick closing plug of resin and sand grains with some tiny pebbles. The base, apex and walls of the single cell were coated with a delicate transparent membrane. This was not a silken cocoon spun by the mature larva, but a secretion, probably silk, deposited by the foundress before she regurgitated the liquid nectar-pollen mixture that constituted the larval food (Krombein 1967).

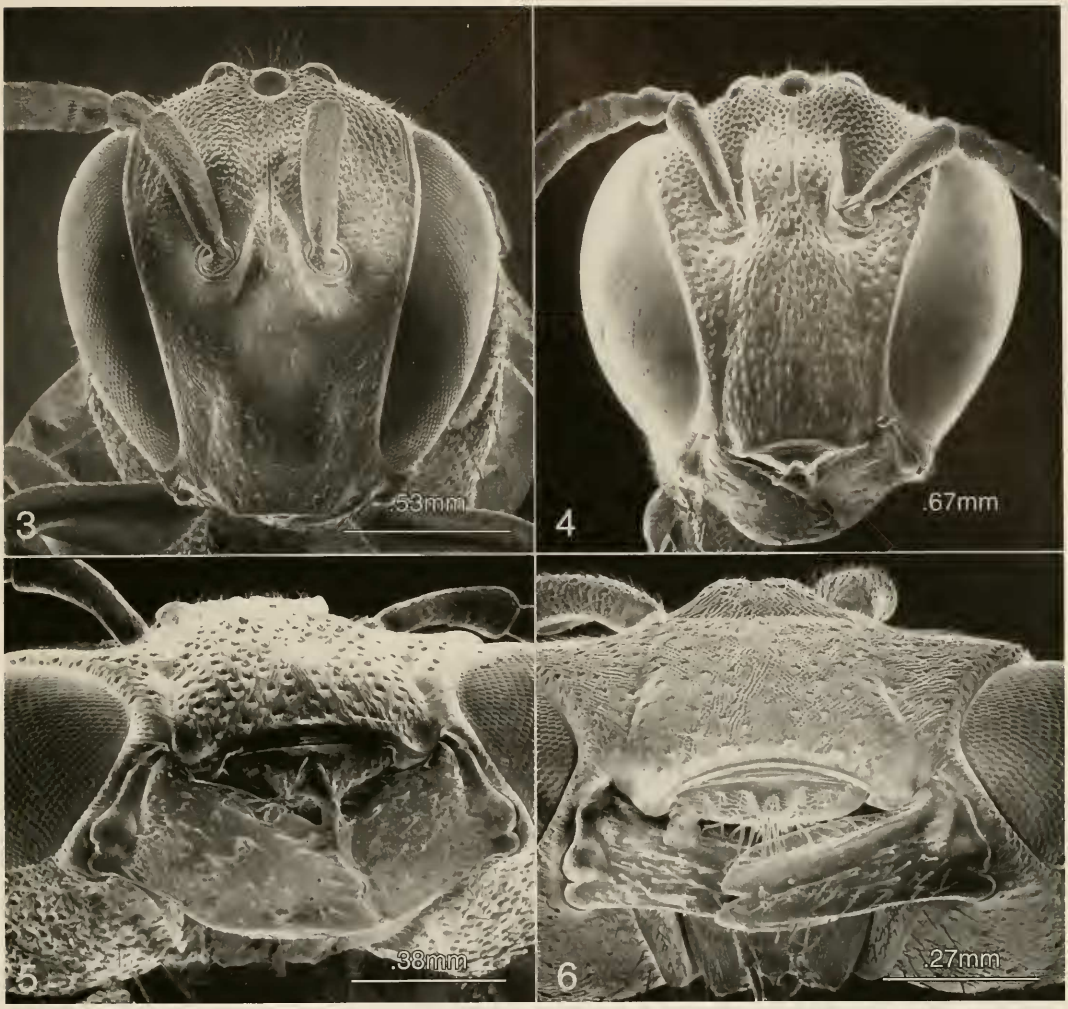
A vestibular cell 4.5 cm long was partially closed by a 2.5 mm thick mass of resin and sand on the bottom of the routing. The partial completion of the vestibular cell suggests the possibility that the female *Hylodynerus wickwari* may have superseded the *Hylaeus sedens.*

Discussion.—The type series of *H. sedens* came from two localities in southern India, but Snelling (1980) included as this taxon one female from Peak View Motel, Kandy, which differed from the type series in having the mandibles blackish brown rather than ferruginous. The single female that we reared from Kandy also has dark rather than reddish mandibles.

The closest relative appears to be *H. eurygnathus* Snelling (1980) also from two localities in southern India and also known only from females.

Males are unknown, but Snelling (1980) described three species from India with enlarged mandibles, two of which may be the opposite sex of the two female species mentioned above.

The species has a broader, flatter mandible than is typical of *Hylaeus,* a distinction that it shares with *H. eurygnathus.* In comparison with the North American *H. modestus* Say, a frontal view of the head shows the relatively large mandibles of *H. sedens* clearly exposed (Fig. 3) while the lower edge of left mandible of *H. modestus* is barely visible (Fig. 4). When the head of *H. sedens* (Fig. 5) is tipped backward, the thin, broadened mandible with small, weak apical tooth, oblique margin above the apical tooth, and close, fine striae on lower half of *H. sedens* (Fig. 5) are a contrast with the narrow, bidentate mandible lacking a cutting edge and striae of *H. modestus* (Fig. 6). The labrum is also markedly different in the two species. Snelling (personal com-




Figs. 3–6. *Hylaeus* species. 3, *H. sedens*, frontal view of head. 4, *H. modestus*, frontal view of head. 5, *H. sedens*, external view of mandibles. 6, *H. modestus*, external view of mandibles.

munication) suggested that the broadened blade-like mandibles in *H. sedens* may be used in gathering resin for nest construction. Such nesting behavior certainly is an additional strong argument for assigning it to a new subgenus.

This is the first report of a species of *Hylaeus* using a mixture of resin and sand in nest construction. *Hylaeus (H.) modestus* usually makes a series of cells whose walls and partitions are made of a delicate, transparent membrane secreted by the foundress, although occasionally the cells may be separated by a thin partition of compacted wood fibers (Krombein 1967).

Megachilidae

*Anthidiellum butarsis* Griswold

(Fig. 7)

We obtained only one nest #18 of this species from a bundle of traps placed in a crotch of a small clove tree. Probing with a grass stem on 5 April showed that this 3 mm wide routing was partially filled, so we placed the trap in a sealed Whirl-pak. The female emerged from the trap the next day.

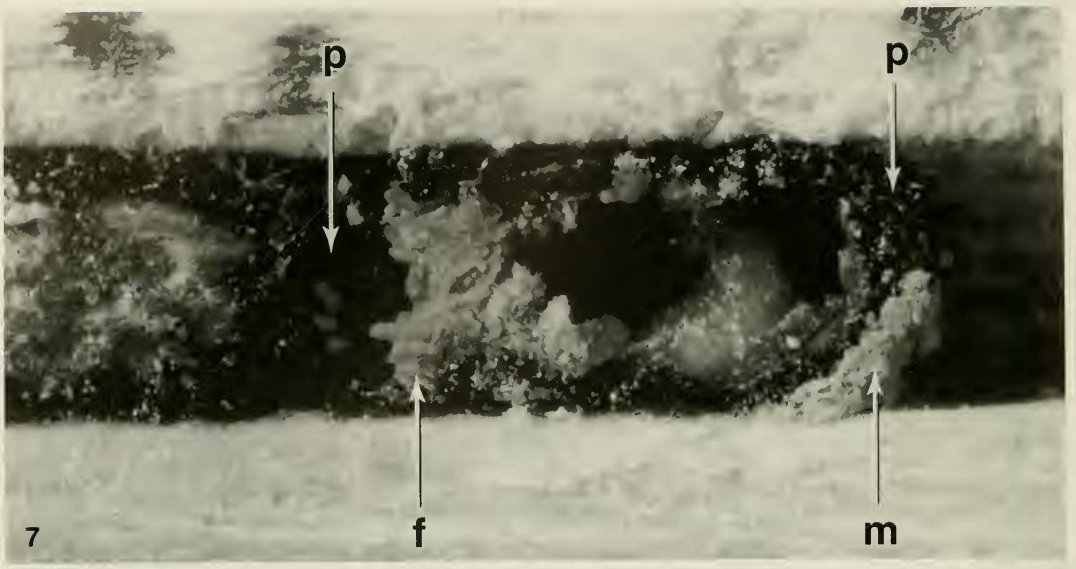



Fig. 7. *Anthidiellum butarsis,* cell 1 (m, mud; p, partition of resin; f, fecal pellets) and basal half of cell 2.

We split open the trap on 5 May. The basal 3.4 cm of the routing was empty and capped partially by a narrow, small bit of mud (Fig. 7, m) and then completely by a thin partition of resin (Fig. 7, p); apparently, the bee had superseded a mason wasp or bee. The next 5 cm contained a series of seven cocoons each separated by a thin partition of resin, and the cell walls also were coated with resin. Numerous small drops of resin were on the walls of the next 3.7 cm and the outer 3 cm contained no resin.

We opened the cocoons in cells 1, 6 and 7 on 30 May and found a viable, curled up, post-defecated larva in each. The rodlike fecal pellets were voided at the outer end of the cell and formed a crown around the apex of the cocoon (Fig. 7, f). The anterior end of the cocoon had a small median nipple. Three females were collected from this nest in addition to the foundress.

*Anthidiellum krombeini* Griswold

This small anthidiine occupied two traps. The entrance of nest #5 was sealed with resin on 1 April and placed in a sealed Whirl-pak. We split it open on 5 May and found that there was a 6 mm thick plug of resin mixed with debris at the basal end of the routing. The next 11 cm of the routing was empty and sealed by a plug of resin 7 mm thick. Then there were four cells, each containing a cocoon 5 mm long. The cell walls were covered with a thin coat of resin; the partitions between the cells were thin septa of resin except that the outermost cell had a plug of resin 5 mm thick. The remainder of the routing consisted of an empty vestibular cell 7 mm long including the 1 mm thick entrance seal. The routing was 3 mm wide and 5 mm deep. There was no emergence by 31 May, but on 3 June two males and a female had emerged and were dead in the Whirl-pak.

The second nest #21 was gathered on 5 April and by probing with a grass stem was found to be partially occupied. We split open the trap on 5 May and found a partition of resin 0.5 mm thick 8.8 cm from the empty basal end of the 4 mm wide routing. The first cell was 7 mm long and contained a moribund bee larva that had consumed only half of the mass of pollen and nectar provided. The next two cells, 8 and 7 mm long, contained light tan, shiny cocoons 5 mm long. As in the first nest, the cell walls were thinly coated with resin, and the cells were capped by thin partitions of resin.

There were bits of resin on the walls between cell 3 and the entrance suggesting that we gathered the nest while the foundress was still actively nesting. As in the first nest, adult emergence occurred between 31 May and 3 June. There was a dead male, undoubtedly from cell 2, in the Whirl-pak on the latter date. Within the nest was a fragmented, fully eclosed male, the undoubted occupant of cell 3, that had been disarticulated by the occupant of cell 2 in its efforts to leave the nest.

Adult emergence through the partitions capping the cells made it impossible to determine whether the cocoon had a median nipple and whether the feces formed a crown around the anterior end of the cocoon.

## Acknowledgments

We thank T. L. Griswold, Bee Biology and Systematics Laboratory, Utah State University, Logan, UT, for describing *Anthidiellum butarsis* and *A. krombeini* that we had reared or collected by net in Kandy. We are indebted to John Norden for his help in setting out and tending traps that were placed too high for us to reach easily. Arnold Norden assisted with this effort and with some collecting by hand net and is thanked as well. Also, we appreciate the efforts of D. Wijayasinghe who placed several traps at her home in Palapathwela.

We are grateful to R. R. Snelling, Natural History Museum of Los Angeles County, CA, for identifying *Hylaeus sedens* Snelling, and to W. P. Wijesinghe, City College of New York for identification of spiders. Identifications of wasps are by KVK as follows: Vespidae by comparison with specimens identified by the late J. van der Vecht; Pompilidae by comparison with specimens identified by R. Wahis; and Sphecidae by comparison with specimens identified by A. V. Antropov (*Pison*) and the late K. Tsuneki (*Trypoxylon*). We thank Suzanne W. T. Batra and Roy R. Snelling for their very helpful reviews of a draft of this contribution. The scanning electron micrographs were prepared by BBN. Within the Smithsonian we thank Susann G. Braden, Scanning Electron Microscope Laboratory, for technical assistance, and George L. Venable for skillful preparation of the plates.

This work was supported in part by the Smithsonian Krombein Endowment Fund and a Research Opportunity Fund award to KVK, and a Senior Fulbright Fellowship award to BBN.

## Literature Cited

Cooper, K. W. 1953. Biology of eumenine wasps. I. The ecology, predation and competition of *Ancistrocerus antilope* (Panzer). Transactions of the American Entomological Society 79: 13–35.

Griswold, T. 2001. Two new species of trap-nesting Anthidiini (Hymenoptera: Megachilidae) from Sri Lanka. Proceedings of the Entomological Society of Washington 103:269–273.

Krombein, K. V. 1967. Trap-nesting wasps and bees: life histories, nests and associates. Smithsonian Press, Washington. 570 pp.

Medler, J. T. and R. E. Fye. 1956. Biology of *Ancistrocerus antilope* (Panzer) in trap-nests in Wisconsin. Annals of the Entomological Society of America 49: 97–102.

Snelling, R. R. 1980. New bees of the genus *Hylaeus* from Sri Lanka and India (Hymenoptera: Colletidae). Contributions in Science, Natural History Museum of Los Angeles County, No. 328. 18 pp.